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ABSTRACT—A survey was conducted among conservation officers in Minnesota to investigate predation by dogs (Canis familiaris) on the whitetail deer (Odocoileus virginianus) and the distribution of dog-killed deer within the state. Of the 124 conservation officers checked, 95 confirmed 407 deer killed by dogs from April 1, 1975, through March 31, 1976. Officers also received 1,483 complaints of dogs chasing deer and 626 dogs were destroyed in this activity. Ninety-four percent of these dogs were thought to be domestic, as opposed to feral. The effects of long-distance chases of deer by dogs, prey selectivity and the profile of the free-roaming dog also are discussed.

Much research has been conducted in the past on the wolf (Canis lupus) by various investigators (Stenlund, 1955; Mech 1966a, 1970; Pimlott et al., 1969), probably making that animal the most extensively studied wild canid. The domestic dog (Canis familiaris), on the other hand, has received little attention. Yet in a nationwide survey, the dog was identified as the number-one killer of wildlife. More than 20,000 deer were reported killed in 32 states, based on adjusted estimates from known kills and on opinion estimates (Denny, 1974).

Studies thus far on dog predation have been concentrated in the southern and northeastern states (Progulske et al., 1958; Barick, 1969; Perry et al., 1970; Scott, 1971). These works identify those predatory dogs as free-roaming or feral. Free-roaming dogs are those housed and fed on a regular basis by man, yet free to harass wildlife and livestock. True feral dogs are those existing entirely in a state of nature, feeding and reproducing without any contact with or control by man.

McKnight (1964) conducted a nationwide mail survey which revealed feral dog populations in almost every state that responded to the survey; and Morrison (1968) estimated there were about 300,000 feral dogs in Georgia. Although the numbers of feral dogs appear to be quite large in the southeast, it is free-roaming dogs that account for the most predation (Denney, 1974) in most states, and feral dogs are not a significant problem in most areas.

The question then arises as to free-roaming dog numbers in Minnesota or any other state. Beck, in a speech delivered before the National Conference on the Ecology of the Surplus Dog and Cat Problem (1974), stated that 38 percent of all households in the United States have dogs, and there's an average of 1.4 dogs per dog-owning household. Beck cited other studies which reported one dog to every 5.99 people. This correlates with findings of an American Humane Association survey (1972) that used a ratio of one dog for every 5.9 persons.

According to the 1970 U.S. Census, Minnesota has 3,805,069 people. Using Beck's ratio of 1 dog/5.99 people, there would be an estimated 635,237 dogs in the state. Beck (1973), in his study of stray dogs, figured one-third to one-half of owned dogs are allowed to run free. This would imply that Minnesota has between 209,628 to 317,618 dogs potentially harmful to wildlife. How many of these would chase deer if given the opportunity cannot be answered. Fox (1971) states that despite thousands of years of domestication, many dogs have not lost the basic urges to hunt and chase moving things.

The purpose of this present study, therefore, is to determine the impact of dog predation in the state of Minnesota. Although livestock losses to dog predation can be severe (Denney estimates such loss to exceed $5 million nationwide), this investigation will concern itself only with predation on the whitetail deer (Odocoileus virginianus). Besides being a valuable big game species in the state, it was felt that deer losses would provide a better common denominator for comparative purposes than would livestock losses.

Survey of Conservation Officers

A two-page survey was prepared and mailed to all 124 active state conservation officers in April, 1976. The conservation officers come under the division of enforcement of the Minnesota Department of Natural Resources (DNR) which functions through six administrative regions (Figure 1). The first mailing was a bulk mailing sent to the six regional supervisors, who then mailed surveys to the individual officers under their jurisdiction. The regional supervisors themselves were not included in the survey. The conservation officers were instructed to complete the survey and return it to their respective supervisors. This method of distributing the survey was chosen because it was felt it would achieve maximum response.

By July, 1976, all six regions had returned their completed surveys and a second mailing was initiated in order to improve the percentage of return. This second mailing was sent directly to those conservation officers who did not reply to the first.

The survey itself consisted of 15 questions or completions. The time period it covered was from April 1, 1975, through March 31, 1976. This period was chosen rather than a calendar year because it included one entire winter season as opposed to the last half and first half of two separate seasons if a calendar year had been used. Only one year's time was covered because it was felt that asking for data covering several successive years would reduce the response.

Answers to the questions were then analyzed and average values were obtained where appropriate. The objective questions were extapolated to estimate figures based on a 100 percent response. Data were broken down to the number of deer killed by dogs per DNR region expressed as a function of population and area.

Responses from 78 percent

The initial mailing of the survey through the regional supervisors resulted in a 44 percent return. The second

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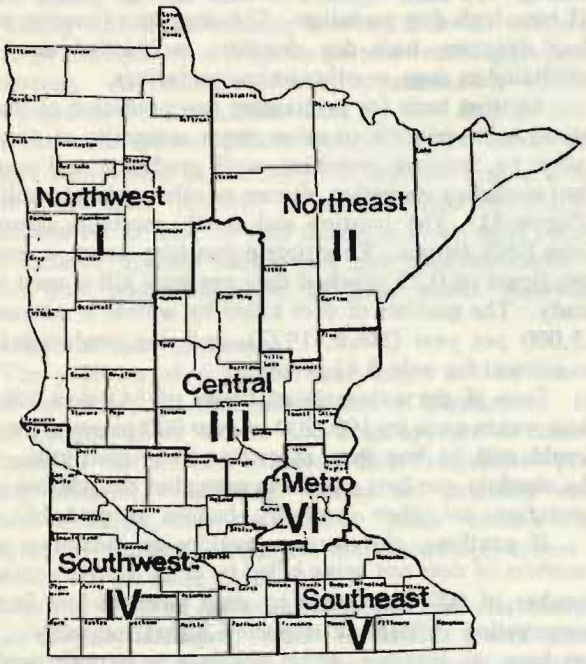

Figure 1. Minnesota Department of Natural Resources (DNR) administrative regions.

Figure 2. Minnesota Deer Management Units (DMU).

mailing direct to the conservation officers raised the total return to 78 percent. This compares to an 82.5 percent response in a survey of game wardens by Perry et al. (1970) and 68 percent in Denney's survey (1974). Of the 124 conservation officers surveyed, 97 replied, but two of the surveys were rejected due to improper completion. The data are broken down in this report by the six DNR regions.

The total deer mortality of 6,539 animals does not include those deer possibly killed by dogs and wolves. These particular survey questions led to some misinterpretation. Upon analyzing the returns, it was realized that answers to the second part of these questions were interpreted by some officers to mean the number of deer they thought were being killed by dogs or wolves in their overall region, whether the kills were actually located or not. The purpose of the question was to define the number of deer killed by some type of canid and then isolate those kills the officers felt for sure were killed either by dogs or wolves with the remaining "possibles" being classified merely as canid-killed deer. The second parts of these two questions concerning mortality by predation of dogs and wolves, therefore, become strictly opinion answers.

The question concerning poaching losses brought responses of limited value. Many officers did not answer this question because they had no idea of poaching losses, and any figure given would be of doubtful value, at best. Many conservation officers admitted tha poaching was a serious problem in their areas but could not provide accurate figures reflecting this problem.

The number of traffic-killed deer (4,574) is considered an accurate figure. Although some deer are killed and kept without any report of the accident being made, conservation officers learn and record most of the road-killed deer in their areas.

The number of deer the officers felt were positively killed by dogs (407) and the number of known deer killed by wolves (188) probably reflects the minimum mortality, covering only the deer investigated.

The total number of dogs killed either by conservation officers or the public (626) is also a minimum figure. Many officers commented that several dogs are killed and never reported by the public because they fear incurring civil suits by owners of the dogs. By Minnesota law, any citizen can destroy any dog seen chasing or otherwise harassing deer. Legal right notwithstanding, apparently lawsuits have been instigated by owners whose deer-chasing dogs had been shot.

Of those dogs killed for chasing deer, conservation officers felt the overwhelming majority (94 percent) were domestic dogs as defined in the survey. No criteria were established for differentiating between domestic and feral dogs, thus this response is subjective. Perhaps those dogs wearing collars or appearing reasonably well-fed were considered domestic but, as it stands, this is a speculative opinion. Feral dogs have been distinguished from domestic dogs by their aggressive behavior when trapped (Scott et al., 1973), but no positive methods for making this distinction among dead animals are known.

DNR Region IV reported the highest percentage of feral dogs (13.3 percent). Some of the officers from this region stated there were packs of true feral dogs inhabiting bottomlands along the Minnesota River. Although the responses are subjective, they agree with Denney's (1974) findings which indicate very few large populations of feral dogs exist in most states.

The number of complaints of dog harassment is an indirect indication of the intensity of dog activity. If a dog-killed deer is considered the ultimate proof of dog predation, then a comparison of complaints received and dog-killed deer found offer one index of predation (Figure 4).

Criteria for distinguishing predators

For the majority of responding officers, the problem of differentiating between dog-killed and wolf-killed deer was easy--there being no wolves to their respective areas. The second most mentioned clue was tracks. Although it is fairly easy to distinguish tracks of a small dog, the differences are not as apparent between large dogs and wolves. The third most popular criteria offered was that the deer had not

been eaten. Many individuals, either laymen or professionals, feel this is a valid distinction. The location of the kill was considered by 12 responding officers to be an indicator of dog predation. Generally, this meant the officer felt the kill took place much too close to human habitation to have been done by wolves. Type of would was next mentioned, meaning location of the wounds on the deer's body and the magnitude of damage. Personal experience was cited by six officers as their method of distinguishing the types of kills. Usually, these officers had several years experience in the field and many observations of both dog-killed and wolf-killed deer. Three officers stated they had actually witnessed kills.

Comparing data by regions

To fairly compare the DNR regions, the quantitative data were extrapolated to a 100 percent response based on the percent return of each of the six DNR regions. This offers a more accurate portrayal of the situation with a smaller percentage of error than if the raw data were used to present an overall picture using only actual survey results. In addition, extrapolation of the data permits the different regions to be compared on an equal basis. This treatment of the data results in a statewide total of 541 deer kills by dogs, almost 2,000 complaints, and more than 800 dogs killed.

The number of known wolf-killed deer is smaller, but this should not be construed to mean more deer are being killed by dogs than by wolves. This lower number is more of a reflection that fewer wolf-killed deer are actually found. In general, most dog predation takes place within five miles of a town or community (Progulske et al., 1958; Hodge, 1976), so it seems reasonable to expect the survey to report more finds of dog-killed deer because the chances of detection are increased.

To analyze the number of dog-killed deer by DNR region, certain assumptions must be made. One is the number of dogs, and thus the number of free-roaming dogs, is proportional to human population. A second assumption is that even though deer densities are not homogeneous throughout the state, they could be homogeneous over large areas involving several counties.

The DNR has divided the state into eight Deer Management Units (DMU) (Figure 2). The only deer density data available are based on these DMU's, which cut across DNR regional boundaries, making it difficult to correlate DNR regions and DMU's. In general, however, deer densities are higher in the northern DMU's, which encompass most of regions I, II and III. For example, known densities for 1976 show the Rainy River DMU having 10 deer per square mile; Itasca DMU, 10 deer per square mile; and Mille Lacs DMU, 8.6 deer per square mile. This compares with the southern Big Woods DMU having only 3.2 deer per square mile and the Prairie DMU, 1.3 deer per square mile. (DNR data).

The DNR regions are fairly homogeneous as to topography, population densities, etc. and it is assumed that deer densities are approximately the same throughout a given region. Thus, large blocks of the state can be compared with each other on the basis of numbers of deer killed, population and area (figure 3).

A more critical comparison is shown in Figure 3a, which relates the six regions by the number of deer killed to the number of people (and thus the number of dogs) within each region. Comparison of areas by this ratio is important in that it indicates areas which, for some reason, are experiencing more intense deer predation by dogs. Regions II and III have high dog predation. This may be a function of high deer densities, high dog densities, wolf-killed deer being attributed to dogs, or other unknown factors.

Another basis for positioning dog predation in the state would be to relate it to other major categories of deer mortality, i.e. hunting, poaching, wolf predation and road kills (but excluding starvation, disease or other natural conditions) (Figure 5). The hunting and traffic mortality figures are from DNR figures. To estimate poaching losses, a comparative figure of 0.75 poached deer per legal kill is used in this study. The number of deer killed by wolves is estimated at 15,000 per year (Mech, 1977), and dog predation is said to account for only 0.42 percent.

Even if the extrapolated figure of 541 deer killed by dogs was in error by 100, 200 or even 900 percent, the figure would still be less than mortality from road kills. Thus, the absolute numbers may be in error, but the relation of dog predation to other mortality factors is probably valid.

If anything, this survey provides an indication of the numbers of deer not being killed by dogs. Even an estimated number of 609 deer killed by dogs gives no hint from the conservation officers of suspected higher mortality. There has been no evidence, either absolute or hypothetical, that dog predation is a major factor of direct deer mortality.

However, there have been cases of one or a few dogs killing large numbers of deer without eating them. In other

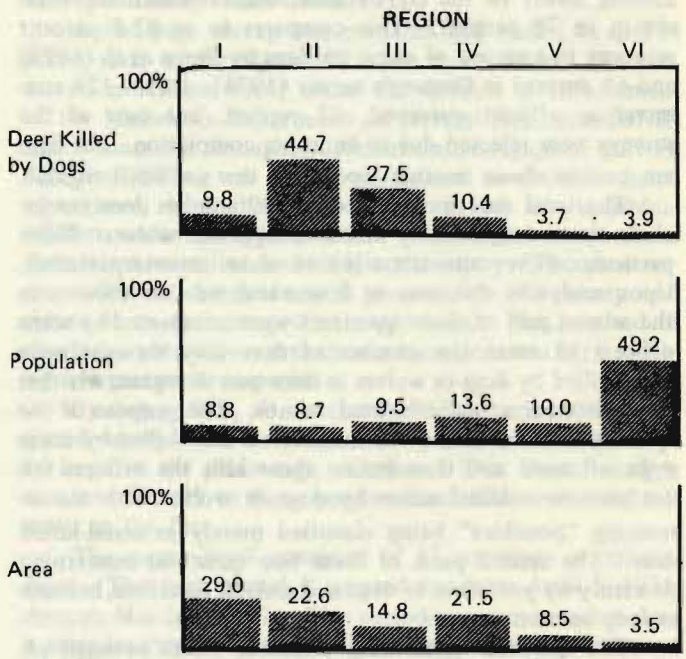

Figure 3. Comparison of DNR regions by percent of total number deer killed by dogs, total population and total area of state.

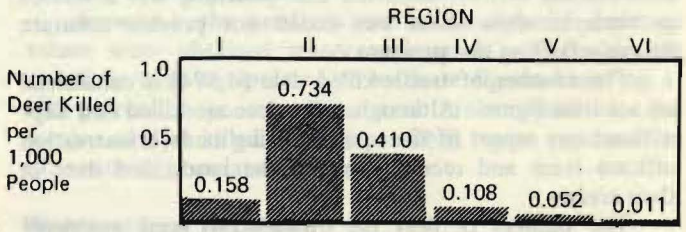

Figure 3a. Comparison of DNR regions by ratio of number of deer killed per 1,000 people (State ratio: 0.142).

words, killing for the sake of killing. Beck (1974) states that killing without consuming is often observed with dogs and is an example of a behavior pattern resulting from domestication. As evidence of this, approximately 40 deer were killed in St. Croix State Park by two dogs in 1969. Also, one conservation officer reported in the survey that 22 deer were killed in March, 1977, by one dog in a ten-square block area. Another officer estimated one dog was responsible for at least 50 deer deaths in a two week period. Such isolated massive kills could give the impression of higher dog predation than actually exists statewide.

The effects of deer harassment

The problem of dogs and deer might not be one of direct mortality, but an insidious one of harassment. Research conducted on wolves and dogs appears to show a fundamental difference between their respective prey-chasing behavior. Although wolves are probably more efficient in killing, they are quick to "judge" when a chase is apparently fruitless. Dogs, on the other hand, appear to chase deer for the sheer joy of chasing.

Mech (1966a) in his work on moose/wolf relationships on Isle Royale, Michigan, found the furthest a wolf chased a moose was three miles. In 32 out of 41 such chases, the wolves gave up in less than half a mile. As for wolves chasing deer, Mech (1966) observed a wolf pack begin pursuit of a deer but quit in less than one minute. Mech and Frenzel (1971) cited several chases of deer by wolves. The longest was four miles, which the authors considered exceptional. In most chases observed, the wolves quit running within 250 yards.

Dogs, however, have been well documented for lengthy chases. In discussing escape tactics of deer, Barkalow et al. (1950) observed one deer being chased by dogs for 1.5 hours. Progulske et al. (1958) cited a chase that lasted 0.5 hours and covered a straight-line distance of 3.25 miles. Corbett et al. (1971) studied chases of deer by dogs. In 20 observed chases of eight deer, the average time of pursuit was 54 minutes and average distance covered was 2.36 miles. The maximum duration recorded was 165 minutes; the maximum distance 6.77 miles. Sweeney et al. (1971) documented 65 chases of deer by dogs. These chases averaged 33 minutes in a range of three to 155 minutes. Distances averaged 2.4 miles, ranging from 0.2 to 13.4 miles. In a single observation of an adult buck and a feral dog in New York, Jackson et al. (1973) estimated the chase covered a distance of at least three miles. Gipson et al. (1975), in 61 chases of deer by dogs, found an average of 40 minutes (range: 5-117 minutes) and 1.75 miles (range:0.3-5.1 miles).

Usually deer attempt to outrun a pursuing canid. In lengthy chases by dogs, however, deer often adopt escape tactics but some tactics have proved fatal. Sweeney et al. (1971) described several tactics in his observations of hounds chasing deer: deer will use speed and endurance to outdistance dogs; deer will run complicated, circuitous patterns; deer will cross trails with other deer or join with other deer temporarily; deer will enter water. Sweeney found that deer using a circuitous pattern would often stop running, perhaps to determine if the dogs were still trailing or to conserve energy. Mech (1966a) described the same behavior for moose being pursued by wolves.

Deer have been known to take drastic measures to escape. Barkalow et al. (1950) observed a deer plunge into a creek after being pursued for an hour and a half by dogs. It remained in the icy water for half an hour with only the top of its head exposed.

There appears to be sufficient evidence indicating that dogs chase deer for greater periods and longer distances than do wolves, sometimes forcing the deer to adopt unusual behavior to achieve escape. What, then, are the effects of such chases on deer?

Several researchers have determined some results of such chases and theorized possible implications. Schoonmaker (1938), Progulske et al. (1958), Sweeney et al. (1971) and Gipson et al. (1975) all found that deer are likely to leave their home range when pursued by dogs. Entering unfamiliar territory might increase the chances of an accident, resulting in immediate, or delayed, mortality. The possibility of accident is also increased in night chases. (Scott, 1971).

Giles (1960) stated that damage to deer as a result of being chased manifests itself through shortening of required feeding time, exhaustion of does' during late pregnancy and shock for deer driven into icy waters. Giles noted one occasion of a deer developing a respiratory ailment and dying as a result of cold-water shock. He further cited an area where more than 20 deer died as a result of being driven into a particular wire while being chased by dogs. Barick (1969) felt many deaths occurred among deer chased into the paths of cars or trains and driven into fences. In Denney's survey (1974), Connecticut authorities estimated 450 deer were killed on highways as a result of being chased by dogs. Corbett et al. (1971) suspected many physical injuries, such as cuts, bruises and broken bones, were incurred by deer being chased through rough terrain.

Some counter indications observed

Not all workers feel that dog harassment has a debilitating effect on deer, though. Marchinton et al. (1970) found no evidence of detrimental changes in behavior or other ill effects of deer chased by dogs. Gavitt (1973) found no significant difference in fawns per doe surviving to late summer between deer run by dogs and those never chased. Nor did he find permanent changes of home ranges as a result of dog chasing, although some temporary changes were noted. Gipson et al. (1975) cited several instances of deer using water to elude dogs with no apparent deleterious "cold-water shock."

Direct mortality of deer by dogs may not be a significant factor in the Minnesota herd. But if the estimated figure 200,000-300,000 free-roaming dogs in the state is accepted, the implications of the impact dogs have on deer is great.

Dog predation and prey selectivity

One area of dog predation that has received little attention is the matter of prey selectivity. It is generally accepted that wolves kill a higher proportion of young-of-the-year and older age deer (Pimlott, 1967); or sick, abnormal or otherwise debilitated deer (Mech et al., 1971). The result of this selectivity is popularly called the "sanitation effect."

Do dogs serve the same function? From what is presently known, it appears they do. Corbett et al. (1971) examined two deer known to have been killed by dogs. One was eight years old, the other ten and both were heavily parasitized. In a discussion on dog/deer relationships, Phillip Gipson found that only two out of 24 known dog-killed deer could be considered healthy (Denney, 1974).

Kuehn (1977) conducted an age/sex study of the 1969 Labrador retrievers or German Shepherds. Giles (1960) felt

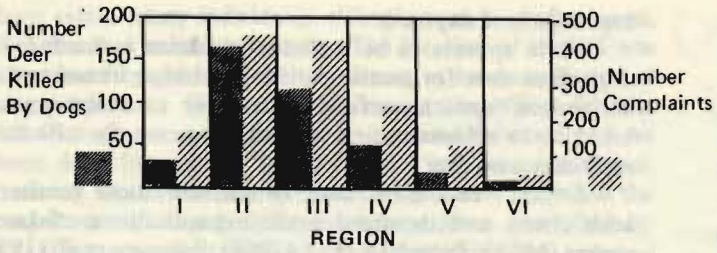

Figure 4. Number of deer killed by dogs related to number of complaints of dogs chasing deer.

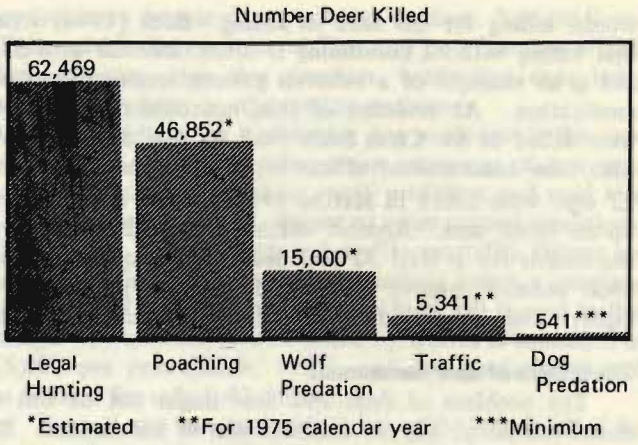

Figure 5. Comparison of deer mortality factors in Minnesota for period of April 1, 1975 to March 31, 1976.

St. Croix State Park deer kill and found the average age to be 6.26 years (not all deer examined). This compares to Mech's study (1971) in which the average age of wolf-killed deer was 4.7 years, significantly older than either hunter-killed deer or theoretical age profiles developed for the deer herd.

Based on the above, it appears dogs are removing the same types of deer as are the wolves. But the impact, of hundreds or thousands of prime, healthy deer being chased by dogs cannot be determined.

Profile of the free-roaming dog

This survey as well as other studies indicate there are few truly feral dogs in most states. The majority of dog problems arise from the uncontrolled, or free-roaming dog. Sometimes though, dog packs are comprised of both feral and free-roaming dogs - the free-roaming dogs apparently joining and leaving the feral pack at will (Scott, 1973). Oftentimes packs are generated by several dogs gathering around a bitch in heat (Denney, 1974).

Some general comments can be made on the types and structure of free-roaming dogs involved in deer harassment. Hodge (1976) observed that such dogs usually run in small packs of two or three and usually consist of Airedales, the most destructive breeds involved in predation on deer were hounds, German Shepherds and Airedales. Cochran (1967) stated the worst deer damage was done by such large and medium sized dogs as Airedales, Collies, German Shepherds and hounds. He also found mongrels particularly destructive. In general, Gavitt (1973) found hounds to be more effective and persistent trailers of deer, while non-hounds were faster.

Perry et al. (1970) stated that a mutualistic relationship probably exists in a pack between dogs that track by sight and those that track by scent. These relationships were noted also by a conservation officer, who cited an incident where the baying of a beagle chasing a deer attracted larger, faster dogs from surrounding farms who quickly took up the chase.

Denney (1974) felt that otherwise well-behaved dogs can be gripped by a "pack mania" when involved in a chasing incident with other dogs.

The impact of dog predation on the whitetail deer in Minnesota may not be absolute mortality, but rather a subtle weakening of the herd through constant harassment. The effects become more pronounced when deer numbers are low (Cochran, 1967).

In addition, it could be said that dog predation represents an unjustified drain on state revenue. The value of deer killed by dogs, based on hunter contribution per deer to the state, is $316,967. The 1975-76 market dollar value of this "lost" meat is $32,460 (DNR figures). It would appear dog predation, if unchecked, could be a financially, if not ecologically, unacceptable problem within the state.

This survey, as an overview of the situation in Minnesota, showed that deer were indeed being killed by dogs, but that exceedingly large numbers are not being killed by dogs. The survey is just the first step in dealing with the problem of dog predation. Much work needs to be done to answer the many questions the survey raised. Furthermore, in Minnesota's present condition of declining deer numbers, increased poaching and increasing wolf predation, dog predation can quickly become a significant factor to the deer population.

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